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COMMUNICATIONS INTELLIGENCE: TRANSCRIBER OUTPUT ENHANCEMENT

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HUMAN FACTORS TECHNICAL AREA

U. S. Army
Research Institute for the Behavioral and Social Sciences

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A workflow model of major transcriber functions was developed and time data for these functions were collected on 52 operational personnel. A time analysis was performed with respect to individual functions and logical sets of functions for a representative sample of the operationally meaningful groups of transcribers. The time analysis of transcriber functions indicated that about one-third of productive time was spent in the Listen, Rock, and Search functions and another one-third in doing these functions in conjunction

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with others. About 11% of the transcribers' time was spent in obtaining help from reference material, 5% in the tape changing functions, and 8% in team work functions. Differences clearly existed between organizational groups in the time spent on specific transcriber functions. Development of procedures to enable transcribers to exploit digitization and computer storage of taped communications should improve productivity at least 10% to 20% by eliminating search and tape changing functions, by reducing time spent in getting help from reference material and other transcribers and in giving help, and improving exploitation of source material.

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FOREWORD

The Human Factors Technical Area of the Army Research Institute (ARI) is concerned with the demands of increasingly complex battlefield systems that are used to acquire, transmit, process, disseminate, and utilize information. This increased complexity places greater demands upon the operator interacting with the machine system. Research in this area is focused on human performance problems related to interactions within command and control centers as well as on issues of systems development. Such research is concerned with software development, topographic products and procedures, tactical symbology, user-oriented systems, information management, staff operations and procedures, decision support, and sensor systems integration and utilization.

One area of concern in sensor systems integration and utilization is the enhancement of communications intelligence (COMINT) through human factors research. Although ARI has conducted several research projects in COMINT, a comprehensive research program is required to enable research and operational personnel to critically evaluate and pinpoint high priority research issues based on potential payoff. This report outlines a research program in COMINT produced as a quick reaction technical advisory service (TAS). The research program is based upon a summary of past research related to COMINT, an empirical analysis of the time spent on major transcriber functions, and interviews with experienced transcribers.

Research in sensor systems integration and utilization is conducted as an in-house effort in close cooperation with operational personnel and augmented through contracts. This report resulted from an in-house research effort augmented by contract number DAAG29-76-D-0100 with Batelle Columbus Laboratories. It is responsive to Army Project 2Q763743A774 and the intelligence community requirements.

The cooperation of the participating transcribers of the operational groups visited was essential to this report. A special note of appreciation is due to Mr. J. Gurin, Dr. J. Brosil, and Mr. A. Baciewicz for their direction, assistance, and innovative ideas reflected in this report.

JOSEPH ZEIDNER
Technical Director

COMMUNICATIONS INTELLIGENCE: *TRANSCRIBER OUTPUT ENHANCEMENT*

BRIEF

Requirement:

To determine the time-important relationships of the major transcriber functions and identify requirements for human factors research to improve overall transcriber output.

Procedure:

A workflow model of major transcriber functions was developed with operational personnel. Time data for these functions were collected on 52 operational personnel and analyzed with respect to individual functions and logical sets of functions for a representative sample and for operationally meaningful groups of transcribers. Research reports relevant to human factors in communications intelligence were reviewed and summarized. Operational transcribers were interviewed concerning problem areas.

Findings:

The time analysis of transcriber functions indicated that about one-third of productive time (not including breaks and administration) was spent in the Listen, Rock, and Search functions and another one-third in doing these functions in conjunction with others. About 11% of the transcriber's time was spent in obtaining help from reference material, 5% in the tape changing functions, and 8% in team work functions. Differences clearly existed between organizational groups in the time spent on specific transcriber functions.

Utilization of Findings:

A systematic human factors research program in communications intelligence should provide payoff in several areas. Digitization and computer storage of taped communications should save 10% to 20% of the transcriber's productive time by eliminating search and tape changing functions and by reducing time spent in getting help from reference material and other transcribers and in giving help. Research and studies designed to aid the transcriber should consider differences in operations between organizational groups. Based on an analysis of the above results, a review of recent research, and problem areas indicated by experienced transcribers, a program of human factors research to improve overall transcriber output was developed.

COMMUNICATIONS INTELLIGENCE: TRANSCRIBER OUTPUT ENHANCEMENT

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INTRODUCTION

This project was the result of a technical advisory service concerning the feasibility of employing human factors research methodology to improve the overall output of communications intelligence. The focal point of the project was the job of the transcriber. The research goal was to improve the transcriber's output in terms of time required, accuracy, completeness, operational usefulness, and timeliness.

In human factors efforts it is necessary to identify the various human-element functions in the system and to assess the relative priorities of these functions according to criticality to systems objectives and costs, such as time, equipment, and support needed. A simple workflow diagram or model of the transcriber functions with attendant priorities provides a ready reference for insuring that each function is at least considered and that appropriate effort is placed on each according to established priorities. Such a description of the transcriber would be especially valuable to nontranscribers (including researchers and systems designers) who support the transcription system and would give them an appreciation and a "feel" for the entire system. A useful and perhaps critical adjunct to the workflow model is a description of how operational requirements and collection means impinge on the job and how the organizational structure relates to it.

The development of communications intelligence (COMINT) from foreign voice radio transmission depends on the selective extraction of information from a number of such transmissions and the skillful integration of these pieces of information into a comprehensible intelligence report. The extraction may take place in real time or later, from transmissions recorded on magnetic tape or other storage media. The task of extracting intelligence information from foreign voice radio transmissions is that of the transcribers. They are trained linguists with additional training and/or experience in all or most of the following: operation of intercept equipment, doctrine and order of battle of potential enemies, and preparation of verbatim transcriptions or summaries (gists) of these transmissions in either the original language or English.

The level of sophistication of the equipment used by the transcriber could vary widely. A simple manual system may consist of only a pair of earphones and controls for the radio receiver; the transcriber listens in real time and simultaneously types or writes a transcription or a gist. A dictionary might be the transcriber's only aid.

At the other extreme, a computer-controlled system could store and provide the transmissions to be processed to the transcriber upon request, perhaps with some enhancement of readability. The transcriber would translate and type the transcription of summary on a cathode-ray tube (CRT) console, which would display the report format and permit immediate corrections and/or changes. The system would automatically edit the report. When the

end-product is complete, it would be logged into computer memory where it could be retrieved by the next person in the chain and displayed on the CRT and/or reproduced as a hard-copy printout. In the process of preparing the transcription or gist, the transcribers might have access to a variety of aids displayed on the CRT at their stations. Intercommunications links with other transcribers, analysts, and supervisory personnel might be easily available.

OBJECTIVES

The specific objectives of the research were to

1. Develop a general workflow model of the transcriber's job,
2. Determine the time-importance relationship of the various parts of the transcriber's job, and
3. Identify human factors areas to be considered in a program of research to improve transcriber's output.

The workflow model and a time analysis of the specific transcriber functions developed with operational personnel are reported, a literature review of research pertaining to communications intelligence is summarized, and in conjunction with the workflow analysis and literature review, interviews with operational personnel were used to identify the human factors research areas relating to improving transcriber output report.

TIME ANALYSIS OF MAJOR TRANSCRIBER FUNCTIONS

Specifications of Transcriber Functions

The duties and qualifications of the voice transcriber (MOSC 98G20) in the U.S. Army are specified in Change 7 to Army Regulation 611-201 (C7) dated 31 January 1977 (see Appendix A).

Thus far, the duties of the transcriber have been described in general terms. On the job, a transcriber performs several observable functions. The workflow chart shown in Table 1 is based on observations of transcribers at work as well as interviews with transcribers and supervisory personnel in operational settings. The activities are listed in the order in which they are normally carried out in a non-real-time mode. The flow chart assumes a single tape containing a number of different transmissions. The transcriber listens to the tape recording, rejects some conversations as unimportant or unreadable, and transcribes or gists the rest depending on their importance.

The process described in the flow chart is primarily manual transcription. If the process were assisted by automation, most steps would still be conducted, but the nature of the activity would be modified. The reader can easily generalize this model to real-time or other more complex systems.

Table 1

Transcriber Workflow Chart

Activity sequence	Remarks
1. Pretranscription	Reads messages, instructions from supervisors, etc.
2. Obtains tape	It is assumed that tapes are kept in a central repository and that reel jackets carry identification data and other relevant information to assist and direct transcriber on transcription format.
3. Mounts tape	
4. Enters appropriate header data	If CRT console, appropriate report format is called up and displayed on the CRT. This information is obtained principally from sources described under Activity 2.
5. May study working aids	
6. Searches	This step may be repeated after each conversation. Transports tape at fast forward to a conversation.
7. Previews tape[a]	May listen to several conversations. May replay portions. May make decision as to disposition. May transcribe.
8. Rewinds tape/fast forward	Returns to beginning of first conversation, if tape was previewed.
9. Listens,[b] listens and types, types	Classifies conversation as to type of transcription required and types report or enters on CRT: Nil--rejects conversation as not important or unreadable. Gist--summarizes conversation--may transcribe parts verbatim Verbatim--transcribes exactly all or most of conversation.
10. Rocks	Replays difficult words and/or phrases several times.

Table 1

Transcriber Workflow Chart (Continued)

Activity sequence	Remarks
11. Uses aids/obtains help, gives help	Refers to references, other transcribers, and analysts. May provide technical assistance to other transcribers on request. May be done in conjunction with typing, entering, listening, or rocking.
12. Other	Performs administrative functions. Takes breaks. Performs maintenance. Checks on computer or equipment malfunctions.
13. Logs transcription	Checker performs quality control. May confer with checker. Gist may be returned by analyst for verbatim transcription.
14. Returns to No. 7 or replaces tape and returns to No. 2	If last conversation, rewinds tape and returns it. If typed, transcription of entire tape may be filed at this time.

[a] Preview activity: this step differs from job of scanner, where one person is assigned to scan whole tape prior to detailed analysis; steps are (a) scan conversation by conversation; (b) nil, gist, or occasionally verbatim some conversations; and (c) relay rest to others.

[b] Job of transcribing varies based on a number of dimensions: formatted messages versus nonformatted messages, language type, term versus near-real-time, geographic area, one-way versus two-way conversations, clarity of tapes, etc.

Selection of Functions

Transcription occurs in several different areas in the communications intelligence field. Analysts in some COMINT systems have been transcribers and continue to use some of the skills learned as transcribers. The checker, who assures quality control of the transcription product, is a highly experienced transcriber. Because of time constraints, these two tasks (or roles) were not included in the present time analysis study. However, team chiefs and scanners were included because most of their work is highly similar to that done by the transcribers.

To reduce analyses to a reasonable size, only the task of transcribing one foreign language in a non-real-time mode was considered. However, the type of conversation was not restricted; for example, the format and geographic origin of the conversations varied, and both one-way and two-way conversations were included.

Within these constraints, the transcriber workflow chart (Table 1) was converted into observable job functions (see the function column in Figure 1) for use in observing the amount of time each transcriber function was performed. Pretranscription activity was not included, but several areas in the workflow chart were more finely defined, e.g., Rock, Rock and Type, Rock and Enter, and Rock and Use Aids.

Observation Procedures

Two highly experienced transcribers first briefed the entire team of transcriber participants on the purpose of the research and the nature of the observations to be made. The names of the observed transcribers were not recorded. The effect of being observed was minimized; the observers were as unobtrusive as possible and did not talk to the transcribers or interfere in their normal routine.

Observers used a Time Analysis Record, similar to that shown in Figure 1 (which evolved from the earlier versions), and filled in the most frequently observed functions. The last half of the function column varied; if a function did not occur, the observers did not add it to the list. The observer filled in the header information and then observed the transcriber at work. He entered the time next to whatever functions the transcriber was performing (for example, as shown in Figure 1, 090000 was written next to "Listen"). When the transcriber began a new function, the time was again written next to that function--but displaced to the right, and a line was drawn between the two times. For example, Figure 1 shows that 090015, or 15 seconds past 9, was written opposite Listen and Enter. In this manner, the amount of time spent on a function and the sequence of functions could easily be determined. Generally, a function that lasted less than 10 seconds could not be reliably observed and was not recorded (this occurred infrequently). A transcriber was observed for about 1 hour, and, if time permitted, the procedure was repeated for the next randomly selected transcriber.

Generally the observation period was from 0900 to 1100 or 1300 to 1500 to eliminate transition periods such as beginning work, lunch, and leaving

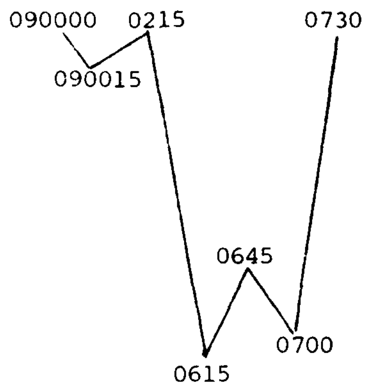
TIME ANALYSIS RECORD

Date ______________ Start Time ___________ Team ______________ Readability___________

Function | Time

Search
Search and Write
Search and Enter
Search and Use Aids
Search and Type
Listen
Listen and Write
Listen and Enter
Listen and Use Aids
Listen and Type
Rock
Rock and Write
Rock and Enter
Rock and Use Aids
Rock and Type
Write
Enter
Use Aids
Type
Get Help
Give Help
Change Tape
Rewind
Fast Forward
Mount Tape
Obtain Tape
Enter and Use Aids
Type and Rewind
Rock and Check

Listen and Check
Read and Check
Administration
Breaks
Maintenance



REMARKS:

Figure 1. General format of Time Analysis Record.

work. Although this procedure biased the sampling across time, it was necessary because of administrative and time constraints.

Sampling

The total population sampled consisted of six organizational groups, each composed of several teams of 4 to 10 transcribers. Each team of transcribers was organizationally different and usually functionally different, varying in such things as quality and type of input, type of target, equipment and aids used, and whether or not scanning of tapes occurred.

A stratified sample from the six transcriber groups was planned. However, one organizational group could not be observed, and certain teams within some groups were unavailable. Thus, although comparisons between groups as well as population estimates can be made, a true random sampling was not obtained. If each team had been sampled, comparisons could have been made between individual teams, combinations of teams, or groups. This procedure would have involved an excessive amount of time for data collection without a corresponding assured gain in useful knowledge.

The sampling was further restricted in that transcribers doing checking (quality control) and trainees were not included. Although some trainees were observed, they were included as a separate group and the data were not used in the population estimates.

Data Analysis

Of the 53 observation sessions (Table 2), 1 session was discarded because of atypical equipment malfunction and 5 sessions using trainees were not included in the major analysis. Of the 47 remaining observation sessions, 31 were selected randomly within groups as a representative, stratified sample of the total population of interest (Table 3). The percentage of transcribers in the groups in the representative sample were proportional to the percentages in the population. The groups differed on the same variables mentioned above for the teams but were more clearly defined. For example, one group used only typewriters for preparing the transcripts, whereas others used only CRT consoles. Since two of the groups (Groups 2 and 6) were composed partially of teams using prescanned tapes, these were analyzed separately (2S and 6S) in the group analysis (Table 2).

All observations were converted from minutes and seconds to decimal-minutes and then normalized to a common base of 60 minutes (not all observation periods were exactly 60 minutes in length). Average times for each function were obtained for the representative samples.

The data were again normalized to 60 minutes after eliminating breaks, administration, and maintenance. Although these functions are a necessary part of the transcriber job, they are not typically amenable to change or improvement, and chance variations in these functions would affect some of the comparisons in later analyses. This second normalization of the data conceptually converts the data to only those functions normally associated with the essential features describing the job of the transcriber.

Table 2

Total Sample by Man Number[a] (N = 52)

Group							
1	2	2S[b]	3	4	6	5S	T[c]
11	15	48	5	1	13	37	4
12	17	49	6	2	24	38	14
51	18	50	7	3	25	39	16
52	19		9	43	26	40	20
53	47		10	44	27	41	23
54			21	45	28	42	
			22	46	29		
					30		
					31		
					32		
					34		
					35		
					36		

[a]Groups were assigned numbers for identification purposes.

[b]The letter "S" designates a group in which scanning is used to screen material.

[c]The letter "T" designates trainees.

Table 3

Representative Sample by Man Number

Group				
1	2	3	4	6
11	15	5	2	24
12	17	6	43	25
51	18	7	44	27
53	19	9	45	35
	47	10		36
	48	21		37
	49	22		39
	50			42

Results

General. The results are presented first in terms of the individual functions summarized for the "representative sample" of transcribers. Next, individual functions are combined to provide two different, logical sets of more general functions representing the broader aspects of transcription. These same sets of general functions are used also to present the total-sample data for the transcriber groups. Finally, the sets of functions are used in a comparison of two observers to examine the stability of the data and provide suggestions for better control in similar future analyses.

Using these data, average times for the representative samples were obtained on two combinations of functions. The transcriber mainly is either listening (Listen, Search, or Rock) to a tape, producing a hard-copy transcript (Write, Enter, or Type), or doing both of these at once (e.g., Listen and Write). For simplicity's sake, rather than looking at mean times for each of the 34 functions in Figure 1, one can consider combinations of functions together. Two sets were chosen for analysis.

The first set (Figure 2) of combinations is composed of relatively pure functions of inputting words, using aids, getting or giving help on a transcription, and changing the reel of tape; it also is composed of mixed functions titled "Search+," "Listen+," and Rock+," wherein the transcriber is doing Search, Listen, or Rock, respectively, but may also be doing two functions at the same time (such as Search and Write, Rock and Enter, etc.). The second set (Figure 3) is similar but gives more weight to input functions and combines the pure Search, Listen, and Rock functions into an Audio function.

Individual Functions--Representative Sample. Table 4 presents the average time for each transcription function observed and for subtotals of groups of functions for the representative sample of transcribers. Most of the transcribers' time is spent in listening. Search, Listen, and Rock functions account for 33 minutes of every hour (however, transcribers also report or use aids while listening). This set of functions should be examined closely to determine if new aids, techniques, procedures, training, etc., could be used to save time. For example, if conversations were digitized and stored in a computer, "search time" (2.4 minutes) and the time associated with "changing tapes" (2.4 minutes) could be eliminated to allow the transcriber 8% more time for listening, reporting, etc. Similarly, additional transcriber time in the functions of Get/Give Help (4.5 minutes) could be saved by the use of digital speech because the transcriber would not need to leave the station and "plug" into another tape recorder to help another transcriber. Finally, automation aids would save time in the function Use Aids (2.9 minutes) because the transcriber would not have to thumb through a dictionary or other aid to find information.

A considerable amount of the transcriber's time is spent in the Rock functions (11.2 minutes, or 19%). Typically, the transcriber rocks only when encountering problems with words, phrases, sentences, etc. The problem may be caused by low intelligibility (e.g., poor signal-to-noise ratio (S/N) or poor speaker characteristics); lack of knowledge (an idiom, seldom used or technical words, or lack of experience), or special words (names of people, places, or things not encountered before). Speech-enhancement

SET A

Functions involving only Input	Write, Enter, and/or Type.
Functions involving primarily Use of Aids	Use Aids and Enter and Use Aids.
Functions involving Search+	Search and Search and Write, Enter, Use Aids, or Type.
Functions involving Listen+	Listening; Read and Check; and Listen and Write, Enter, Use Aids, Type, or Check.
Functions involving Rock+	Rock and Rock and Write, Enter, Use Aids, Type, or Check.
Functions of getting or giving Help on a transcription	Get Help and/or Give Help.
Functions associated with a Tape Change on player	Change Tape, Rewind, Fast Forward, Mount Tape, Obtain Tape and/or Type and Rewind.

Figure 2. Combinations of individual functions in Set A.

SET B

Functions involving Write+	Write, Search and Write, Listen and Write, and Rock and Write.
Functions involving Enter+[a]	Enter, Search and Enter, Listen and Enter, and Rock and Enter.
Functions involving Use Aids+	Use Aids, Search and Use Aids, Listen and Use Aids, Rock and Use Aids, and Enter and Use Aids.
Functions involving Type+	Type, Search and Type, Listen and Type, Rock and Type, and Type and Rewind.
Functions involving only use of Audio equipment	Search, Listen, and Rock.
Other	All other functions.

[a]Except Enter and Use Aids.

Figure 3. Combinations of individual functions in Set B.

Table 4

Average Time by Function for Representative Sample of Transcribers (N = 31)

Code	Function	Average time[a]
01	Write	.3
02	Enter	5.4
03	Use Aids	2.9
04	Type	.4
	Total	9.0
10	Search	2.3
11	Search & Write	.0
12	Search & Enter	.0
13	Search & Use Aids	.0
14	Search & Type	.1
	Total	2.4
20	Listen	13.6
21	Listen & Write	1.3
22	Listen & Enter	2.6
23	Listen & Use Aids	.7
24	Listen & Type	2.0
	Total	20.2
30	Rock	2.4
31	Rock & Write	4.4
32	Rock & Enter	2.3
33	Rock & Use Aids	1.6
34	Rock & Type	.4
	Total	11.2
45	Get Help	2.0
46	Give Help	2.4
	Total	4.5
55	Change Tape	.7
56	Rewind	.8
57	Fast Forward	.1
58	Mount Tape	.3
59	Obtain Tape	.6
	Total	2.4
63	Enter & Use Aids	.2
64	Type & Rewind	.0
65	Rock & Check	.0
66	Listen & Check	.0
67	Read & Check	.1
	Total	.3

Table 4

Average Time by Function for Representative Sample of Transcribers (N = 31) (Continued)

Code	Function	Average time[a]
95	Administration	5.6
96	Breaks	4.2
97	Maintenance	.3
	Total	10.1

[a]Number of minutes out of observed hour.

techniques, special training on words found to give difficulty, reference aids to proper names, etc., may reduce the time spent in this function.

Sets of Functions--Representative Sample. The last three functions in Table 4 (Administration, Breaks, and Maintenance) represent necessary but nonproductive aspects of the work of transcription (10.1 minutes). Thus, in a transcriber hour, only 50 minutes are devoted to the transcription process. Individual observation sessions varied greatly in the time observed for these three functions, depending on whether or not a break was taken during the observation period (0-20 minutes) and other factors.

This variation in nonproductive work time (i.e., nontranscription functions) caused a corresponding variation in the time observed for productive transcriptions functions during the observation period. To eliminate variations due to nonproductive functions and still retain a 1-hour baseline, these times were eliminated from each observation session. The times observed for the rest of the functions were increased proportionately to total 1 hour. The following results are presented in terms of this 1-hour productive time.

Table 5 presents the average productive time in terms of the sets of general functions (the individual functions combined in different ways). The general function is defined by the individual functions involved. In Set A, input is defined by codes 01, 02, and 04, which are Write, Enter, Type (see Table 4 for code definitions). In Set B, Write+ is defined by 01, 11, 21, and 31, which are Write, Search and Write, Listen and Write, and Rock and Write in Table 4 (or all the functions involving Write).

Most of the transcriber's time is spent in listening (plus other activities) to tapes--Search+, Listen+, and Rock+ equal 40.6 minutes, or about 70%, of the productive time (Table 5, Set A). However, 22.1 minutes, or 37%, of productive time is spent on the pure functions of listening--Search, Listen, and Rock, or Audio (Table 5, Set B). Obviously, future research should be directed toward these transcriber functions.

As indicated earlier, computer-stored, digitized speech in lieu of tape recordings could save some transcriber time. It would eliminate the Search+ and Tape Change functions for a savings of about 6.4 minutes, or 10% of the transcriber's productive time (Table 5, Set A). Similarly, digitized speech could save some of the transcriber's time in getting and giving help (Help category of Set A equals 5.0 minutes, or 8% of productive time). An intercom and simple computer relay of the portion of speech causing trouble to a transcriber could eliminate the time required for the physical movement of transcribers in getting or giving help.

Another possible computer-supported aid to transcription is a computerized reference system that would quickly display materials such as dictionaries. Set B data indicate that 6.5 minutes, or 11%, of the transcriber's time is spent in Use Aids+, part of which might be saved by easy access to reference material and work aids.

The transcriber appears to spend relatively little time (5.9 minutes) on the mechanical aspects of producing a report (Table 5, Set A, Input

Table 5

Average Productive Time by General Function for Representative Sample of Transcribers (N = 31)

Type of function	Average time[a]
Set A	
Input (01, 02, & 04)[b]	6.9
Use Aids (03, 63)	3.8
Search+ (10-14)	3.0
Listen (20-24, 66, & 67)	23.8
Rock+ (30-34, & 65)	13.8
Help (45 & 46)	5.0
Tape Change (55-59, & 64)	3.4
Set B	
Write+ (01, 11, 21, & 31)	7.5
Enter+ (02, 12, 22, & 32)	11.6
Use Aids+ (03, 13, 23, 33, & 63)	6.5
Type+ (04, 14, 24, 34, & 64)	3.5
Audio (10, 20, & 30)	22.1
Other (all other codes)	8.5

[a]Number of minutes out of observed hour, adjusted by deleting codes 95 through 97 and normalizing to a 1-hour base.

[b]Numbers refer to a code column in Table 4.

category).[1] However, Set B data indicate that considerable time is spent in inputting the report because of frequent listening to the tape while producing the report (Write+, Enter+, and Type+ equal 22.6 minutes, or more than one-third of productive time).

Sets of Functions--Group Comparisons. Table 6 presents the same groupings of transcriber functions shown in Table 5 but for the entire sample, divided into the different organizational groups and trainees. Differences between groups may indicate problem areas to be considered by management and identify those groups that might benefit most from technical improvements and operating changes. (Obviously, some of the differences between groups are due to the characteristics of the particular material on the types typically assigned to each group and are not to be considered here.)

Table 6

Average Productive Time[a] by General Function for Groups of Transcribers

Type of function	Group 1	2	2S	3	4	6	6S	T
Set A								
Input	7.1	6.6	7.4	10.6	8.0	6.9	3.3	3.7
Use Aids	1.8	4.3	6.4	4.7	3.4	3.6	.6	4.2
Search+	9.3	.2	.0	.6	17.6	.1	1.1	6.5
Listen+	24.1	10.8	32.2	20.8	20.0	22.5	34.6	16.7
Rock+	7.3	28.7	5.6	16.2	6.0	16.7	8.0	19.6
Help	3.5	8.2	2.9	1.8	2.8	3.5	7.8	7.1
Tape Change	6.8	1.2	5.5	5.4	2.3	6.9	4.5	2.2
Set B								
Write+	4.8	12.8	.2	13.7	4.2	6.0	2.0	7.6
Enter+	.0	18.4	18.1	10.9	10.8	17.3	18.9	12.0
Use Aids+	2.9	8.6	10.5	6.9	6.6	6.9	3.1	10.4
Type+	25.3	.0	.0	.0	.0	.1	.0	2.6
Audio	16.6	10.8	22.9	20.7	33.3	19.4	23.7	18.0
Other	10.3	9.4	8.4	7.8	5.1	10.4	12.3	9.3

[a]Number of minutes out of observed hour, adjusted by deleting codes 95 through 97 and normalizing to a 1-hour base.

[1]The term report is used to identify the output of the transcriber whether it is a gist, verbatim transcript, or simply an indication that the recording is unreadable or of no importance (NIL).

Considering the potential time savings resulting from the use of digital speech, Groups 1, 4, and trainees would benefit most through reduction of time required in the Search+ functions (9.3, 17.6, and 6.5 productive minutes, respectively). In both the Search+ and Tape Change functions, all groups except Group 2 would gain at least 5 minutes from the use of digital speech.

The use of computerized access to references and ancillary data would benefit ("time-wise") Groups 1 and 6 the least (see Table 6, Set A, Use Aids function; and Set B, Use Aids+ functions).

Considering reporting (Write+, Enter+, and Type+ of Set B), Groups 1 and 2 used the most time and Group 4 used the least time. In reporting, Groups 2 and 3 apparently spent more time than the rest in writing (notes, parts of the report, etc.) before actually entering or typing the report. The determination of specific changes in these functions would depend on the causative factors involved.

Another clear difference between groups in listening functions occurs in the ratio of Listen+ to Rock+. The ratio of Listen+ to Rock+ indicates how much trouble a transcriber is having with a particular message. Most groups spent much more time in Listen+ than in Rock+. However, the reverse was true for Group 2 and trainees.

The above differences between groups could be caused by many factors. Obviously, the various differences in taped material could affect the time spent on different functions by different groups. For example, Group 2 transcribers may have received only tapes with very poor S/N ratio, which caused them to rock more than listen. On the other hand, the trainees were not as experienced and therefore had to rock more often to understand a particular message. Other differences might occur because of procedure or requirements specific to a group. Research to find ways to help the transcriber must be explicitly designed to consider these group differences, understanding that what might be helpful to one group may not be for another.

Sets of Functions--Observer Differences. Comparisons of the average times by sets of functions for the two observers are given in Table 7. These data are based on a sample of 14 transcribers (7 per observer) of the entire sample. The two groups of transcribers were selected so that they were matched on group affiliations and day observed to partially control confounding variations.

Table 7 indicates that the observers tended to agree on what they were observing except in two important areas. Large differences were found in Use Aids of Subset A (5.7 versus 0.8 productive minutes) and in Use Aids+ in Subset B (9.4 versus 1.5 productive minutes). It is difficult to determine why this difference occurred since the use of aids appears to be a readily observable function clearly understood by the two observers, who were highly experienced transcribers.

Table 7

Average Productive Time by General Function for Each Observer (N = 14)

Type of function	Observers' average time[a] T	J
Subset A		
Input	9.0	7.5
Use Aids	5.7	.8
Search+	5.9	3.5
Listen+	9.1	27.9
Rock+	22.4	11.3
Help	5.0	5.4
Tape Change	2.8	3.7
Subset B		
Write+	10.3	14.6
Enter+	9.2	10.8
Use Aids+	9.4	1.5
Type+	6.2	7.7
Audio	17.0	15.5
Other	7.9	9.9

[a]Number of minutes out of observed hour adjusted by deleting codes 95 through 97 and normalizing to a 1-hour base.

The second difference concerns the definitions of Rock and of Listen. Although the observers tended to agree on the Audio functions in Subset B, they clearly disagreed on the Listen+ and Rock+ functions of Subset A. The total time for the two functions combined is similar, but the ratio of Listen+ to Rock+ is reversed. Apparently there was no clearly defined line delineating whether a transcriber was rocking or listening to the message. The observational differences most likely occurred when a transcriber replayed one or two sentences in a message; theoretically this is rocking, but it may appear to be listening. Future observations of transcribers should include careful definitions of the functions and training of the observers prior to collection of data.

Summary of Results and Conclusions

Transcribers, as expected, spent the most time in listening functions--Listen, Rock, and Search--and in other functions such as Write or Type, often

done at the same time. Obviously, research and support should be directed to these areas. Research areas such as compressed speech, intelligibility, and training would aid the Listen functions. Since the time spent in rocking represents a transcriber problem area, research is needed here. The third part of listening, the Search functions, may be eliminated by computer-stored, digitized speech. This would also eliminate the Tape Change functions, for a combined savings of about 10% of the transcriber's productive time. Digitization should also aid in the Help functions, reducing some of the 8% of productive time the transcriber spends in giving and getting aid from associates.

The transcriber also receives help from a variety of reference materials--11% of productive time is spent in these functions. Computerized access to aids should save some time in obtaining reference material.

Differences between the organizational groups clearly exist in the time spent on specific transcriber functions. Research and studies designed to aid the transcriber should consider these differences in operational procedures.

Use of these results and future, similar efforts should consider the following:

1. A large sample and increased observation time, depending on the functions involved.

2. Careful sampling to cover the wide variety of conditions between teams.

3. Thorough training of the observers to insure clear, common definitions of what is to be observed.

4. Sampling across the entire work day, depending upon the functions to be observed.

RELEVANT RESEARCH ON TRANSCRIBER PERFORMANCE

Introduction

This section summarizes research concerning a single job in communications intelligence (COMINT), i.e., the job of the foreign voice transcriber. Critical job tasks entail listening on-line to foreign voice radio transmissions (or off-line to recordings) and preparing written transcriptions or gists of the content of the transmissions. Gists are summaries that abstract the essential elements from a communication and are frequently based on key words.

Much of the available research has been oriented toward speech processing and largely concerns the speaker's production of speech and its transmission. How the speech is modulated by changes in its physical correlates of frequency, amplitude, and time has been examined closely to determine the equipment specifications necessary to obtain acceptable transmission and

reception. Historically, the development of procedures for the quantitative investigation of speech perception was accomplished largely by telephone engineers interested in testing the adequacy of their equipment (Licklider & Miller, 1951).

From the transcriber's point of view, COMINT production begins when the foreign voice transmission has been intercepted and possibly recorded on magnetic tape or other storage medium. The transcriber can have no impact on factors unique to the speaker/speech or the intercept and recording of speech. However, it is erroneous to consider that the characteristics of the recorded materials are necessarily immutable. The playback process can be controlled either automatically or by the listener to enhance the perceived voice quality, filter out noise, and change the speaker's rate in words per minute.

Basic Information

The auditory system is capable of responding to sound pressure level and analysis of sound into frequencies. In regard to the former, the absolute threshold for hearing a sound of 1,000 Hz has been established by the American National Standards Institute as .0002 dynes per square centimeter. Upper boundaries where sound intensity becomes painful are not well defined. The experienced listener may not report pain at an intensity above the level where a less experienced listener has already reported pain, and results differ among investigators. The threshold for a sensation of tickle is reported at 135 decibels (dB) above the absolute threshold, and a pain threshold is reported at about 140 dB above absolute threshold. Much current work is concerned with the establishment of acceptable standards for sound levels that do not damage hearing (Licklider, 1951).

In terms of frequency, the human auditory system is capable of hearing sounds with wave lengths of 20 to 20,000 cycles per second (cps), although the upper limit is much reduced in many older adults. The most important range for speech communication is below 4,000 cps. Of equal importance is the ability of the auditory system to analyze sounds into frequencies and to sense the rapid succession of frequencies involved in speech perception.

In the perception of speech, the intensity required for a listener to follow connected discourse heard through earphones is 24 dB above threshold (Licklider & Miller, 1951). When speech is masked by noise, the relative intensity of the speech (signal) to the noise will determine the intelligibility of the speech. The signal-to-noise ratio (S/N) is used to designate this relation. Licklider and Miller (1951) report that for most noises encountered in practical situations, the S/N should exceed 16 dB for satisfactory communication. If the speech is distorted, e.g., by speaker accent, the S/N must be even higher.

Signal-to-Noise Ratio and Intelligibility

Four experiments (Castelnovo, Tiedemann, & Dobbins, 1963; Stichman & Renaud, 1965; Stichman, 1966, 1967) determined the effects of S/N ratio on

intelligibility of communications. Although the experiments did not include the use of trained transcribers gisting or transcribing foreign voice communications in an operational setting, the results are useful in showing the effect of S/N on intelligibility. As test materials, three of these experiments used the phonetically balanced monosyllabic word lists developed by the Harvard Psycho-Acoustic Laboratory, and the fourth experiment used the sentence intelligibility lists prepared by that laboratory. Sound intensity of the signal was about 75 dB above absolute threshold, and S/N varied from -8 dB to +6 dB for the four experiments. Figure 4 shows combined results of the four experiments. Intelligibility, measured as percentage of scorable words correctly reported, is plotted against S/N ratio for the four experiments. In general, for each decrease of 1 dB in S/N between +6 and -8 dB, there is a 6% decrease in intelligibility (percentage of scorable words correctly reported).

Clearly, S/N is an important variable and should be considered in the designs of systems supporting the transcriber, since it greatly affects the human output of the system. For example, if incoming transmissions could be ranked on the basis of S/N ratio, only the high positive S/N transmissions would be processed when the workload became too heavy for the transcriber. Obviously, S/N would be only one of the variables used in determining the priority assigned to a given transmission. To be effective, this procedure would require an automatic means of measuring the S/N of each incoming transmission and a computer program to determine the priority of transmissions according to S/N ratio and any other pertinent variable.

Frequency Filtering and Intelligibility

Research has been reported (Castelnovo et al., 1967; Licklider, 1951) concerning the effect of excising parts of the speech spectrum on speech intelligibility. The speech spectrum ranges from less than 100 Hz to more than 7,000 Hz, but transmission that ranges from about 200 Hz to 3,500 Hz is adequate. Filters can be used to eliminate or select portions of the frequency range.

The effect on intelligibility of excising portions of the speech spectrum has been described (Licklider, 1951). If all frequencies below 1,000 Hz are eliminated by using a high-pass filter, speech power is reduced by about 80% with a loss in intelligibility of about 10%. Eliminating the low frequencies affects vowels more than consonants, whereas eliminating the high frequencies affects consonants more than vowels.

If broadband white noise masking the entire speech spectrum is encountered at an unfavorable S/N ratio, excising portions of the speech spectrum will not markedly improve the S/N. Research indicates that 2 to 3 hours of practice per day in listening to speech masked by such noise will improve the listener's performance. After 5 or 6 days, a plateau in performance is reached.

If the masking noise falls within one or more well-defined frequency ranges, these frequencies can be eliminated by using appropriate filters, improving the S/N and thus intelligibility (Castelnovo, 1969). For such a

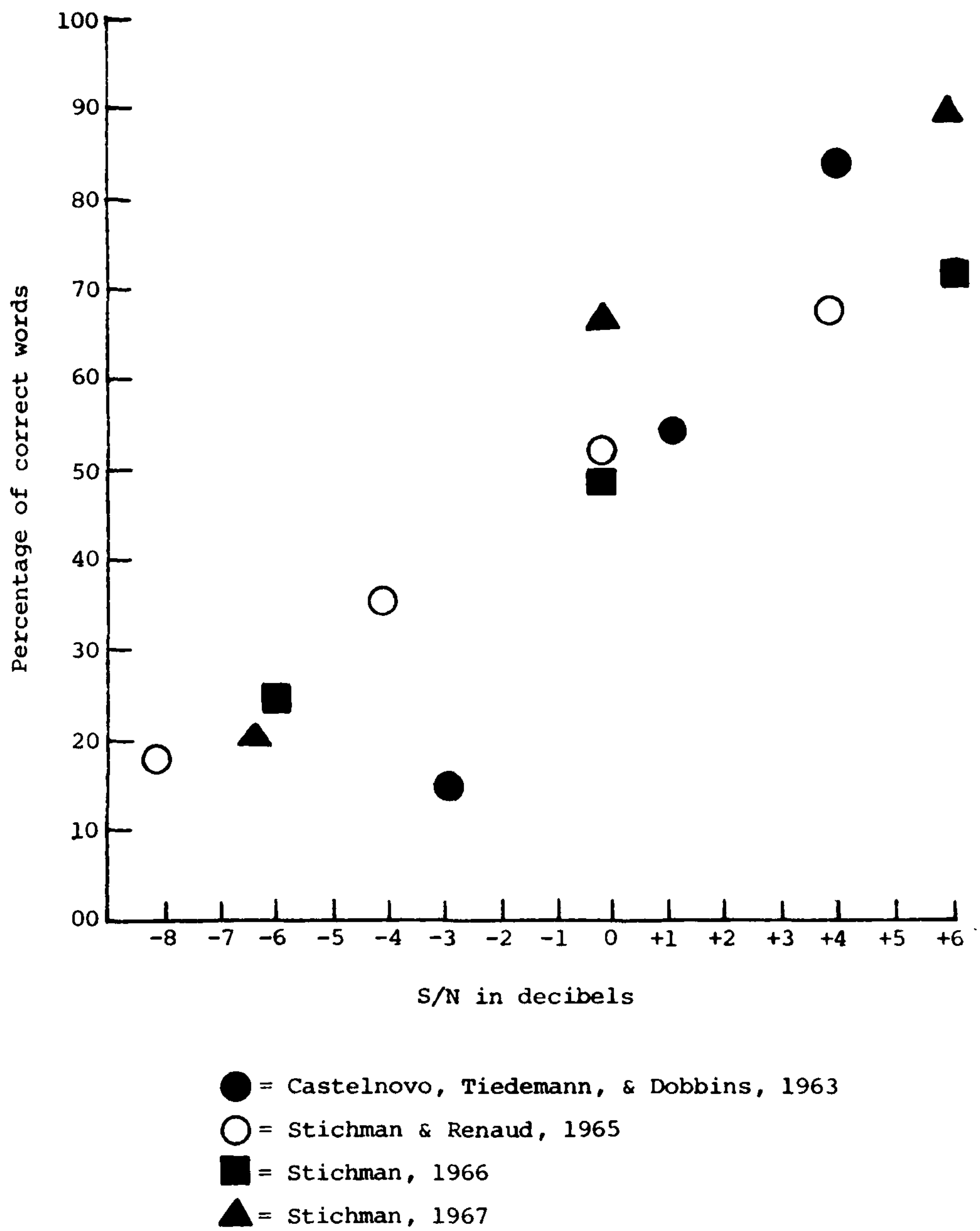


Figure 4. Percentage of words correctly identified as a function of signal-to-noise ratio.

procedure to be maximally useful, equipment capable of sensing the frequency limits of the masking noise is required. The use of digitized speech and computer algorithms to counter sources of noise may provide the ultimate solution.

Speech Compression

The basic work leading to this concept took place in 1950 with a demonstration of the information redundancy in spoken words. It was shown that small segments of the speech signal could be deleted with little loss in intelligibility (Miller & Licklider, 1950). This was followed by the pioneering work of Garvey (1953) in which audio tapes were cut into sections, small sections were discarded, and the remaining portions were spliced together in contiguous fashion. Playback of this shortened version of the original recording took less time and resulted in a faster word rate with unchanged speaker pitch and good intelligibility. This tedious approach was outmoded by the development of electromechanical equipment that accomplished the same thing, and by 1965 it was shown that a computer could be used for this purpose.

Considerable research has taken place on the understanding of time-compressed speech, usually referred to as "compressed speech" when portions of the speech are eliminated as described above (sampling method), or as "speeded speech" when faster playback speeds are used and the pitch of the reproduction is proportional to playback speed. Compressed speech, on the other hand, has normal pitch.

The intelligibility of compressed speech of monosyllabic words was shown to be 90% or higher until about 50% of the speech had been eliminated (Garvey, 1953). It was shown that speeded speech changes vocal pitch and intensity and alters the duration of consonants, vowels, and pauses during speaking (the "Donald Duck" effect). A rapid decline in comprehensibility for compressed speech takes place at about 265 to 300 words per minute (wpm), about twice the normal speech rate (Foulke & Sticht, 1969; deHaan, 1977). The estimated comprehensibility of connected speech has been reported to be about 218 wpm for speeded speech and 266 wpm for compressed speech (deHaan, 1977; deHaan & Schjelderup, 1978). However, only low correlations were found between estimated comprehensibility and comprehension as measured by tests.

Using a different method for estimating comprehensibility, deHaan (1980a, 1980b) determined the speed-performance function for compressed speech. Based on this work, the author suggests that there is a rate limit for comprehensibility of connected speech which is below the limit imposed by speech intelligibility.

Other research found that if compressed speech was heard through earphones, intelligibility could be improved by delaying the signal heard through the second earphone by 7.5 milliseconds (msec). Another method of enhancing intelligibility in compressed speech is to listen to the normally retained portions of speech through one earphone and to the normally discarded samples through the other earphone. This method has been termed "dichotic" speech compression (Gerber, 1968).

An experiment that is directly relevant to transcription used speech compression as a tool to speed up the transcriber's job (Shields, 1975). Thirty-six communications processors listened to taped material at three rates--1.0, 1.5, and 2.0 times normal speed. Listeners were to report the subject matter of the transmission, indicate whether or not they could transcribe and/or gist the content, and rate the overall comprehensibility of the communication. Experienced transcribers rated the completeness and accuracy of the subject matter reports. Results showed that all measures of listener performance declined as a result of the speedup. Since the processors had not been trained in the use of speech compression prior to the experiment, the author recommended additional experimentation.

Lambert et al. (1978) compared the performance of Army enlisted personnel who received different types of training in compressed speech with those who received no training. Although not conclusive, the results indicated that rewards during training tended to improve the final performance using compressed speech.

Gade and Gertman (1979) found that prior forced exposure to highly compressed speech influenced the rate at which listeners could be induced to listen when instructions were given to listen as rapidly as possible but not so rapidly that they could not answer questions. This induced rate was jointly influenced by the forced exposure and the original preference rate.

Foulke and Sticht (1969) placed oral reading rate at a mean value of about 174 wpm and conversational speech at about 125 wpm. Listeners hearing transmitted speech express a preference for about 120 wpm. Regardless of the value used as the rate of the original speech, it appears that the rate can be increased to 250 to 275 wpm before comprehensibility is seriously affected. The utility of speech compression merits additional appraisal. For example, if the scanner in a COMINT system can listen to transmissions at this accelerated rate and effectively rate the transmissions in terms of overall quality, value of content, and so forth, the actual processing time could be reduced materially. Alternatively, if speech expansion can be shown to help process difficult transmissions, this may provide a useful technique for improving the accuracy and completeness of transcriptions or gists.

Work Methods

Several experiments have addressed the problems of work methods and procedures with operational personnel. An experiment (House, 1972) using operational transcribers gisting English language transmissions provides some basic performance data. Another investigation, with similar results, was carried out using four Russian language transmissions and two English language transmissions (House & Cohen, 1971).

House (1972) used two English language transmissions, each 5 minutes in length. The taped materials were recorded under studio conditions and were rated by experienced communications personnel as superior to average communications. Two methods of gisting were used.

Method A required the transcriber to listen to the entire transmission and then write the gist. After the first trial, the transcriber was permitted to follow operational practice--start and stop the tape, rock, replay, etc., at will, until satisfied with the final gist. Method B also required the transcriber to listen to the entire transmission and then prepare a gist based upon the first trial. However, unlike Method A, each of the five subsequent trials were repetitions of the first trial. The transcriber updated the gist at the end of each successive trial but had no option of stopping or starting the tape.

Transcribers under both methods spent about 8 minutes in making the first gist and identified about 42% of the important items; this is similar to on-line gisting. The average final time for transcribers under Method A was about 28 minutes, and the average percentage of important items detected was about 72. Using Method B, transcribers had a fixed time imposed--six trials at 8 minutes per trial--so that time was not a legitimate comparison measure. The average number of important items identified was about 60% for the final level of performance. Transcribers under Method A (the usual off-line or non-real-time method) made from 5 to 33 reversals of the tape player gisting the 5-minute transmissions. The number of reversals gives some indication of the difficulty of the transmission and of the durability requirements of a tape player to be used in an operational area.

In summary, results indicate that repeated listening to the entire transmission does not significantly benefit performance. This does not refer to the operational practice of replaying portions (or rocking) of the transmission whenever the transcriber experiences difficulty.

If the transmissions had been in a foreign language or of poor quality, the time required for gisting probably would have been greater and the number of important items identified probably less. Since the recorded stimulus materials were nearly ideal in this situation and performance was still far from perfect, it seems that there is a demonstrated need to improve the transcription or gisting procedure. Innovative research to isolate the factors involved in transcription and gisting is a necessary antecedent to the systematic design of improved transcriber procedures and job aids.

Research on the relative merits of current operational methods used by transcribers have been compared with experimental work methods in several research efforts (Cohen & Turney, 1974; Cohen, 1975; House & Cohen, 1971; House, 1972; Horner, 1970). Based on perceptions of the operational personnel, work procedures were rated higher for the experimental system (Cohen, 1975). However, working aids were rated as unsatisfactory in both systems. Another investigation (House, 1971) found verbatim transcriptions to be superior to either on-line or off-line gisting in terms of completeness and accuracy. In accuracy and usefulness, off-line gisting was rated only slightly lower than verbatim transcription, whereas on-line gisting was rated much lower. However, not quite half of the transcribers finished the verbatim transcription of one complete transmission in the time required to gist all six transmissions on-line. The implications for person-hour requirements and timeliness of reports heavily favor off-line gisting.

In the same investigation, certain words were found to be more difficult for the participants to recognize than others. This problem could be

corrected by on-the-job training (OJT). A list of words, concepts, or ideas that repeatedly cause transcribers difficulty could be collected and taped. Transcribers could listen to this tape and become familiar with these difficult words and ideas. Similarly, practice tapes for training gisting skills could be developed for use in OJT. In a computerized system, computer-assisted instruction involving the above could be used for each new transcriber, for maintaining transcriber proficiency, or for experienced transcribers working in a new area.

The intuitive concept that transcribers can gist more information when the transmission contains a wealth of critical information than they do when the amount of critical information is sparse was established empirically (Cohen & Turney, 1974). The possibility of examining the tradeoff between time and accuracy of transcriber output was suggested by House and Cohen (1971). If differential situations can be identified in the operational area in which quickness of response is more important than total accuracy, then transcriber procedural requirements can be developed to meet such specific situations.

Man-Machine Interface

In an industrial job analysis, the machines the worker operates are but one of the considerations of the total analysis. Interpersonal relationships with supervisors, peers, and subordinates are considered along with a number of other factors. Later in this report, job satisfaction and motivation will be discussed, as if the interaction between workers and the machines they operate has no influence on job satisfaction. This artificial separation between man-man and man-machine interfaces was deliberate, since human factors issues in the development of hardware for a new system are not often considered before the hardware has been produced.

During system evaluation, a human factors specialist may be called in as an observer. The experimental system design may not have paid sufficient attention to the human factors--placement of controls, location and suitability of displays, and nature and utility of ancillary items of equipment. An added burden is thereby placed on the operator, since the operator must take necessary compensatory action to make the system function. Many of these deficiencies could have been detected and corrected prior to the final design of the experimental system if they had been noted during the breadboard phase of system development.

Two research efforts (Cohen, 1975; Dean, 1970) assessed the man-machine aspects of communication systems. In one study (Dean, 1970) the psychologist took part as an observer during the engineering evaluation test of an experimental system; the goal was to identify design factors that could have an adverse effect on operator performance. In general, the report was favorable. However, it called attention to several elements which would degrade operator performance, but which were correctable without severe modification of the equipment. For example, auxiliary displays were placed in such a way that the operator had to change position to view them easily. This physical shifting took the operator's attention from the main display and distracted the operator from the primary task. Alternative positioning of these additional displays was recommended to correct this problem.

The other investigation (Cohen, 1975) reports the results of a questionnaire approach to assessing the opinions of scanners in an experimental semiautomated system and of operators and transcribers in a standard communication system concerning the utility of their equipment and aspects of the work environment. The man-machine interface was evaluated along four dimensions: (a) acceptability of equipment; (b) frequency of use of a given piece of equipment; (c) ease of operation; and (d) importance of each to the total job. Analysis of the opinions of 13 scanners (experimental system), 40 operators (standard system), and 23 transcribers (standard system) provided the data shown in Table 8.

Table 8

Rated Utility of Equipment

Equipment used by	No. of items rated	Rated acceptable by 85% or more	Rated unacceptable by more than 15%
Operators (40)	34	31	Earphones, intercom, microphone
Transcribers (23)	20	15	Earphones, typewriter, speed control switch, recorder foot switch, millpaper
Scanners (13)	91	89	CRT keyboard, recorder knee switch

Ninety-one parts of experimental system apparatus were evaluated, 96% of which was rated as acceptable and easy to use. Only two parts of the experimental system were rated as unacceptable: the CRT keyboard and the knee-switch (which causes the tape recorder to replay portions of the recording). On the basis of this analysis it was suggested that an alternative device be substituted for the knee switch, leaving the CRT keyboard as the critical consideration for the development of the final system. This demonstrates the advantages of bringing a human factors specialist into system development during earlier rather than later stages.

Motivation and Job Satisfaction

Investigators in this area hold that two major factors influence human performance in complex systems--the job itself and the work organization in which the job is embedded. These two factors affect personnel and determine their level of performance, morale, level of job satisfaction, and behavior.

The incumbents' perceptions of the job are influenced by their attitudes concerning job duties, training for the job, performance standards set for satisfactory job performance, and performance consequences. These factors affect motivation. If the job itself is attractive and interesting, it may be motivating in its own right; this is defined as "intrinsic" motivation. Various job rewards--such as promotion, pay increases, and so forth--are termed "extrinsic" motivation. Elements inherent in the organizational factor are the workers' perceptions of the importance of the job, the nature of the work group, the adequacy of first line supervision, and the feedback they get concerning their performance.

Research in this area is accomplished by surveying the attitudes and opinions of supervisors and subordinates concerning their job duties, training, performance standards and consequences, organizational supervision, work group, job importance, and feedback. To obtain these perceptions, questionnaires are developed that use specific terms associated with the positions being surveyed.

One research effort using this approach (Turney & Cohen, 1976) describes the development of questionnaires, termed Work Environment Questionnaires (WEQ), for operator, analyst, and supervisor in a U.S. Army field station engaged in Morse Code operations; another report (Cohen & Turney, 1976) describes the results of assessing the perceptions and attitudes of the personnel at this station.

Responses to the Work Environment Questionnaire were analyzed for the referenced field station. The results revealed seven major problem areas:

1. Lack of peer group norms that encourage good performance.
2. Insufficient performance feedback.
3. Need for training in supervisory techniques.
4. Role ambiguity and conflict.
5. Inadequate intergroup communication patterns.
6. Lack of clear performance-reward relationships.
7. Ambiguous performance evaluation standards.

Based on such a set of findings, recommendations were made to upper management (the field commander in this instance) for corrective measures. The final action rests with the organization.

Such an approach is not a one-time effort. Research may isolate problem areas and recommend that corrective steps be taken to alleviate the problems, but this does not immunize the organization. Repeated probes should be conducted to verify the continuing state of organizational health.

Selection of Transcriber Trainees

U.S. Army aptitude requirements, as specified in Change 7, Army Regulation 611-201, for selecting personnel for training as transcribers in communication intelligence, are an acceptable score on the language aptitude test (DLAT) and an acceptable score on the General Technical (GT) area of the Armed Services Vocational Aptitude Battery (ASVAB). The adequacy of

these selection measures have been questioned in the light of some research results.

Several documents address this topic (Castelnovo, Tiedemann, & Dobbins, 1963; Castelnovo, Tiedemann, & Skordahl, 1963; Stichman & Renaud, 1965; Stichman, 1966, 1967, 1968). Castelnovo et al. (1963) used 50 military personnel who listened to Sentence Intelligibility Lists at three S/N levels. Their intelligibility scores were correlated with the test scores of these individuals for the 11 tests of the classification battery then in use plus a 12th variable--the ability to play a musical instrument. Individual differences in ability to produce complete and accurate transcripts of voice radio transmissions were predicted by several tests. However, no subset of tests was recommended for selection use. In spite of the authors' expectations, ability to play a musical instrument had a low correlation with transcription ability. These researchers recommended that sets of calibrated materials masked by noise be used as a job sample for selecting trainees.

An investigation of current procedures used in selection of voice processors gathered opinions from a number of operational communications personnel (House & Cohen, 1970). The pervasive opinion was that factors other than foreign language potential should be given consideration in selecting transcriber trainees. Measures of hearing and tonal discrimination, short-term and long-term memory, conceptualization, motivation, and English language ability were recommended.

Licklider and Miller (1951) reviewed individual differences in speech perception. One effort studied the individual differences among listeners by varying the nature of the speech material, the equipment over which it was transmitted, and the noise against which it was heard. Results showed that there was only one significant factor, a listening ability factor that is uncorrelated with the ability to receive telegraphic code in noise. The correlations between listening ability and intelligence, memory span, and speaking ability were all quite low.

The recommendations of these three sources conflict on some points. One recommends the use of measures of short-term and long-term memory, while another finds that memory span (short-term) is not related to listening ability. Whereas the GT score of the ASVAB is a measure of mental alertness (general ability) and is a current trainee requirement, one research effort finds that listenability and general ability are uncorrelated. Despite these contradictions, it seems that there may be promise in searching for other predictors. The job sample approach has the appeal of face validity in that the task used to predict is in some ways similar to the task that the transcriber does on the job. Language aptitude and other selection factors should be considered as well.

Licklider and Miller (1951) conclude their discussion of listeners with the observation:

> There appears to be no better way to teach listeners than to motivate them and have them listen. Even after extensive training, however, normal listeners differ considerably in their ability to understand under difficult conditions.

Obviously, further research is necessary to find the basis of these differences.

Automated Assessment of Transcriber Output

In a computerized system where speech signals are digitized and stored, the computer could be programmed to assign transmissions to transcriber personnel based on the experience and ability of the transcribers. Programs could also be prepared to estimate the expected value of the transcriber's output.

The S/N ratio and the transcribers' confidence in the accuracy of their transcriptions have been shown in research efforts to relate to transcriber output (Castelnovo, Tiedemann, & Dobbins, 1963; Castelnovo, Tiedemann, & Skordahl, 1963; Stichman & Renaud, 1965; Stichman, 1966, 1967, 1968). The S/N ratio of the transmission, the transcriber's confidence rating concerning the accuracy of the transcription, the transcriber's ability index estimated from past performance, message content, and several other measures could be combined by the computer in a regression equation to estimate the accuracy and completeness of the transcription or gist. This information would help the analyst by providing an assessment of how accurately and completely the transmission had been transcribed and, thus, indicate the degree of confidence the analyst could place on the usefulness of its content. The information would also help determine which transcriptions require checking.

Before automated assessment of transcriber output could be implemented, more research would be required; however, the potential payoff should be reasonably high for the amount of effort required.

Summary

Because of a host of operational factors, transcribers will very often receive noisy transmissions. Noise is usually the limiting factor in speech intelligibility, and consequently a number of publications have addressed the noise problem and established acceptable S/N ratios. However, training in listening to speech at unfavorable S/N ratio has been shown to improve performance. When noise is limited to certain bands, suitable filtering may improve the intelligibility of speech.

Research indicates that use of compressed speech will provide the same amount of information in much less time--that is, speech is still intelligible at double the normal rate. It also should be useful for scanning transcriptions to determine those sections that might be worthy of more detailed study or gisting. Use of compressed speech clearly is one way to reduce the time required for transcription, although long-term effects have not been studied. Only extensive experience with speech compression devices in an operational situation will indicate the overall usefulness of this technique.

The importance of work methods has been revealed by several investigations. For example, comparing the operational method of stop, start, replay, and rock with repetitions of the entire transmission has demonstrated

the worth of the former over the latter method. The off-line gisting method was shown to save time and to be almost equivalent to verbatim transcription in another investigation. The research identified a requirement for on-the-job training for certain words, phrases, etc., found to be especially difficult for many transcribers assigned to a particular area.

The importance of the man-machine interface has been shown, and corrective measures to improve this interface have been recommended in several studies. Too much emphasis cannot be placed on the value of human engineering during the original development of a new transcription system.

Organizational development studies reveal the importance of motivational aspects of interpersonal relationships and the entire work environment. Factors that promote job satisfaction and morale cannot be ignored. Periodic surveys of the attitudes and opinions of both supervisors and subordinates are required to establish the sources of job dissatisfaction. When these are found, appropriate changes should be instituted to counteract them.

Selection of transcribers is also a continuing problem. While paper-and-pencil tests are excellent predictors of language ability, they have not been designed to predict overall transcriber ability. It is known that transcribers differ in their abilities to transcribe and gist, but more research is needed to select in advance those who are most capable in these activities.

Research has indicated that several variables (S/N ratio, transcriber's ability, etc.) could be used to predict the accuracy of transcription. This automated assessment of accuracy (and/or completeness) could be used to reduce the transcriber's workload, aid the analyst in using the transcriber's reports, and determine in advance which transcription should be checked.

COMINT has the same basic problem as other intelligence sources--too much raw information is available for the human processor. Some improvement can be achieved through research on the selection and training of the operator: some through research on the basic factors underlying speech recognition and on procedures for improving gisting. Larger improvements are possible through research or new procedures and computerized aids for the transcriber, such as speech compression, prescanning of recordings, quick retrieval of references and other material, etc. With digital speech, synthetic speech, speech recognition systems, and other voice technologies at initial stages of development, neither basic nor applied research should be neglected.

DEFINITION OF RESEARCH AREAS

Earlier portions of this report described the individual functions included in transcription and a time analysis of these activities as they are actually performed in doing the job in one operational installation. In such a detached approach, the transcriber's job can be misunderstood, in that its complexity may be buried in one set of numbers. Numbers do not reflect the effect on the transcriber of being responsible for preparing transcripts or gists of only the important content--as defined (somewhat nebulously) by requirements or essential elements of information.

Transcribers also know that a transcript or gist must be as complete, accurate, and operationally useful as possible and must be prepared in the shortest period of time feasible.

However, until researchers in artificial intelligence accomplish their ultimate goal of devising a system whereby a machine can recognize speech and translate it into any language desired, a person must be the interface. A program of research in human factors to improve the transcriber's performance is essential to maximize output in COMINT systems.

Approach to Program Development

Research ideas were gathered from a review of relevant research reports, from discussions with transcribers and scientists familiar with communication intelligence research, and from introspection based on past research on other areas of intelligence production. The next step was to sort the ideas into categories of related efforts, i.e., research on similar variables, similar transcriber functions, or established human factors areas. A number of projects did not seem to fit into any of the existing categories or combine with any of the other isolates to form a new area. Consequently, a miscellaneous category was established. The labels that have been given the research areas tend to parallel the subordinate headings of Chapter III.

Determination of Baseline Data

This research will assess the performance of transcribers in their normal operational tasks, using selected transmissions representative of the work materials by experts in communications intelligence. The transcribers taking part in the establishment of the baseline data will be selected so as to adequately sample the range of talent available in the operational setting.

The results will serve as reference data for the evaluation of future proposed systems, as well as for the assessment of new transcriber techniques and procedures. The experimental materials and procedures developed will provide a "test bed" that can be used for subsequent assessment. In addition, the baseline data obtained will reveal areas where difficulty is experienced by operators in the current system and may show where procedural changes are needed.

Ideally, some of the studies listed below could be conducted most efficiently in computer-linked systems and are described in that way. They can be carried out in a manual system but will require additional recordkeeping.

Determination of the Utility of Repeated Playback of Same Part of Transmission (Rocks). This effort will assess the relation between the number of replays and the final excellence of the transcriber's output. Accuracy, completeness, usefulness, and time required to make the transcription or gist will be determined.

Determination of Types of Transmission Content That Give Rise to Rocks. A record of the content of those portions of the transmission that cause the transcriber to replay may reveal specific content elements that cause transcribers to replay--difficult words, geographic names, poor signal quality, and so forth. If these are causes common to many transcribers, sets of training materials can be devised and used for on-the-job training. If the causes vary among transcribers but are consistent for a given transcriber, this may provide a guide for use in the assignment of transmissions to specific transcribers and for the identification of individual training requirements.

Determination of Typing Skill Levels Among Transcribers. In the preparation of transcriptions/gists, the transcriber cannot divide attention effectively between listening and looking for the next key to strike. Typing speed should not be a limiting factor in the transcriber's ability to transcribe.

Determination of the Skill Requirements and Work Methods for Transcribing and Gisting. The work methods and skills that are optimal for verbatim transcription may differ from those that are best for gisting. Groups of transcribers who excel in transcription or gisting will be identified along with transcribers who are below average in transcription or gisting. The work methods used by the high and low transcribers in gisting performance will be compared. Similarly, the transcriber work methods used by the high and low transcribers in transcription performance will be compared. The personal skills of the groups will be examined to determine the presence of significant skill differences. If differences are found, the results will be used to guide the development of training materials that can be used to improve transcriber performance in the two types of output.

Communications Properties That Govern Transcription or Gisting Difficulty. The transmission content project is related to this effort. The number of rocks was the indicator of transmission difficulty in the previously referenced project. Here, the measures of difficulty in transcription or gisting will be the accuracy, completeness, operational usefulness, and time required to complete the task. The specific properties of the transmission that are associated with transcription or gisting difficulties will have to be determined through interviews with the individual transcribers and analysis of the transmissions.

Error Analysis of Entire Transcription/Gisting Process by Transcriber Subgroup. The kinds and significance of the errors made in the various subgroups will be determined to provide a clear objective definition of problem areas. The levels of accuracy, completeness, operational usefulness, errors, and time required can be analyzed separately. These data will furnish baseline information. The experimental materials and procedures used in gathering the data will provide an experimental "test-bed" for later research purposes.

Time and Motion and Workflow by Separate Groups. An analysis of the activities performed by the transcriber has been carried out. In a similar manner, a time analysis and workflow description will be developed for the checker, scanner, and analyst. All three of these positions are filled by persons who are or were transcribers. These individuals represent a large

part of the transcription system and have great impact on the information overload both individually and in their interactions with the transcriber.

Analysis of the Number of Reports Filed by Type and the Frequency of Use. To obtain basic information on the frequency with which different types of reports are required, determine the number of nil reports, comment reports, gist reports, and verbatim reports that are logged in by area of interest and source of communication. Determine the number of times each type of report is accessed and the number, by type, that are used in the intelligence report.

Determination of the Average Speech Rate of Transmissions To Be Processed. Speech rate may affect transcriber accuracy and completeness in preparing his transcription or gist. If this is true and speech rate varies considerably among transmissions, this variable could be used in assigning transmissions to various transcribers, based on their skill and experience, or changed to an optimal rate for the transcriber receiving the transmission.

Effect of Signal-to-Noise Ratio (S/N) on Transcription Accuracy, Completeness, and Speed. The literature contains data on the effects of S/N on the intelligibility of English speech when the transcriber records the transcription of gist in English. However, little controlled experimentation on the effects of S/N on the translation of a foreign language and its transcription or gist was found. The determination of the effects of S/N on the transcription of the foreign language transmission is needed.

Determination of the Degree of Agreement on Overall Requirements Among Transcribers and Among Analysts and Between Transcribers and Analysts. This effort will determine the degree of agreement among analysts concerning the overall requirements for essential elements of information (EEI) currently in effect. The agreement among transcribers concerning overall requirements will be determined as well. The degree to which the transcribers' impressions coincide with those of the analysts will be determined.

This would be done not only using stated requirements, "Number of Tanks," but also by presenting a series of typical transmissions to both transcribers and analysts and having them rate each as to their importance.

Replication of Selected Experiments on the Perception of Speech, Using Foreign Language Stimuli. A previous project proposed that the effects of S/N be determined in the situation where the listener must transcribe foreign speech. Other variables, such as intensity, frequency, amplitude, and clipping, might be examined under the same conditions. Speech compression experiments would be another prime candidate.

Improving Intelligibility

Recorded transmission varies greatly in distortion, noise, and speech characteristics. Changes can be made in the quality of the transmission or in the listener's ability to comprehend the speech. The effectiveness of such approaches would be determined by projects such as those described below.

Repeated Listening To Improve Intelligibility. Research has indicated that at favorable S/N ratios, the number of wrong responses decreases with repeated listening, while at unfavorable S/N ratios, the number of wrong responses increases with repeated listening. The number of correct responses increases for all S/N levels studies with repeated listening. If the S/N ratio is unfavorable, it may be inadvisable to make numerous repeats.

Apparent Improvement of "Speaker" Intelligibility. In this effort, an attempt would be made to classify speakers in terms of the dialect spoken, sex, type of work, and so forth. Transcribers would be trained on these particular variations in order to improve their comprehension of such speech differences. This approach actually changes the listener rather than the stimulus, although in some cases (e.g., sex) changes in the stimulus might be attempted.

The Effect of Speech Expansion on Intelligibility. Speech compression techniques can be used to increase or slow down the number of words per minute heard in the replay of a transmission without changing the pitch of the speaker's voice. For difficult transmissions where noise, poor enunciation, difficult context, or other characteristics make intelligibility poor, speech expansion may improve intelligibility. Also, research indicates that sending the transmission to one earphone, followed by sending the same transmission to the other earphone with a 7.5-msec delay improves comprehension.

Improving S/N Ratio To Enhance Intelligibility. If the speech is masked by noise located in relatively narrow bands of the speech spectrum, the noise can be eliminated by using filters that excise the frequencies carrying the noise. Such filtering will improve the S/N ratio and thereby increase the intelligibility of the signal.

Varying Intensity and Frequency To Improve Intelligibility. Providing the transcriber with controls that permit him to vary the pitch and loudness of the speaker's voice in order to maximize intelligibility appears to have merit. Transcribers will have to be instructed in the best ways to handle such controls. Research has shown that if listeners are allowed to set loudness at some preferred level, their performance as measured by intelligibility scores was poorer than when the loudness was set above the preferred level.

Hardware Requirements

Certain approaches for improving transcriber performance suggested in the projects under the various research areas presuppose the existence and availability of specific equipment configurations for their efficient exploitation. The types of equipment needed cannot be specified, but references in the literature suggest that hardware to satisfy these requirements may be within the state-of-the-art.

Equipment for Automatic Determination of S/N Ratio. The S/N ratio of a transmission was proposed as an indicator of the intelligibility of a transmission and would be used as one measure in deciding whether or not to transcribe the transmission. Also, if it is transcribed, this measure of S/N would be used as one variable in estimating the utility of the

transcriber's output. Additionally, the automatic determination of S/N would be u~ed to indicate those transmissions where filtering should be used, if feasible, to improve signal quality.

Equipment To Determine Frequency Limits of Noise and To Automatically Filter Out the Noise To Improve Intelligibility. This equipment would be used in conjunction with that described above. If the S/N value is unfavorable, this equipment would determine the frequency bands in which the masking noise was concentrated, automatically filter the transmission, and thereby improve the S/N and enhance intelligibility.

Equipment for Sampling Speech and Permitting the Compression or Expansion of the Speech To Improve Performance. Such equipment does exist. Several of the projects proposed in the different research areas would employ such equipment. Compressed speech permits the transmission to be heard in less time than it took the speaker to produce it. Listening to transmissions at increased word rates would be useful at least in screening the transmissions to determine those that should be transcribed and by what transcriber. Alternatively, the speech can be expanded so that the word rate of the speaker is reduced. This approach may prove useful in the transcription of difficult transmissions. A computer can accomplish speech sampling; this might be done in a computer-linked COMINT system. However, the use of the computer for this purpose may limit its use for other purposes. The decision concerning the use of a separate piece of equipment for speech sampling, or the use of the central computer for that purpose, must be based on the relative cost of the two approaches.

Transcriber Techniques and Procedures

This area examines the operational techniques and procedures that might be employed by the transcriber, scanner, checker, or analyst to improve individual performance and to increase system output. The separation among jobs is not distinct, since some techniques or procedures used in one job are used in another job as well.

Transcribers

1. Quality Ratings of Voice Transmissions. In one operational unit, transcribers and analysts use two 6-point rating scales to evaluate signal and intelligibility quality of the transmissions processed. It is proposed to determine the usefulness of these scales. The questions to be answered are

- How well do analysts and transcribers agree in their ratings of the same transmissions?
- Are the ratings on the two scales independent?
- How accurate are the ratings, i.e., how well do they predict the intelligibility of the message?

2. Detection of Man and/or Equipment Degradation in Transcribing. The sound reproduction system may suffer a partial failure and produce a degraded playback which the transcriber interprets as an indication that the transmission contains nothing of significance. In another situation, the transcriber may become fatigued and his or her auditory threshold may increase for certain sounds; he or she would make errors in his or her transcription or gist. To guard against either possibility, the use of a standard transmission (which would differ by organizational group) is recommended. The standard transmission would be introduced periodically so that the transcriber would be able to judge whether or not the playback sounded normal. In a computerized system, the computer could be used to check on the performance level of the whole system.

3. Assignment of Easy Transmission to Less Expert Transcribers and Difficult Transmissions to Expert Transcribers. In the initial screening of transmissions, an estimate of the sound quality of the transmission and a rating of the difficulty of the transmission content would be made. Based on these ratings, an overall rating of transmission difficulty would be determined. This rating would be used to guide the assignment of transmission to individual transcribers based on an appraisal of their transcribing skill.

4. Feasibility of Assigning Noisy Transmissions to Transcribers Able To Resist the Masking Effects of Noise. Research indicates that individual listeners differ in their ability to resist masking effects. If transcribers differ appreciably in their ability to resist the masking effects of noise, it may be beneficial to assign important transmissions, masked by noise, to those transcribers who are best able to cope with noise (not necessarily the "best" transcribers).

The amount of variations in S/N ratio, the variations in transcribers' abilities to read through the noise, and the costs in accuracy and time associated with low S/N ratio transmissions would be determined. Selection and training requirements would then be developed to optimize overall group output.

5. Trade-offs Between Time and Accuracy of Transcription or Gist. In one experiment it was found that six on-line gists were made in less time than was required to make a verbatim transcription of one transmission. The gists were not as accurate for the six transmissions in comparison with the verbatim, but the time required was far less. Are there trade-offs possible between time and accuracy? Should only gists be prepared except when the analyst requests verbatim transcripts?

6. Determination of the Level of the Speaker. The level of importance of the speaker is of value in assessing the significance of the communication. The development of a checklist to assess this factor would consider the jargon used by the speaker, level of the words used, pronunciation, and so forth. From such a checklist it may be possible to infer something about the vocation of the speaker, his or her position in the hierarchy, and so forth.

7. Feasibility of Using Multiple Transcribers on Important Transmissions. Research indicates that the use of multiple transcribers for the

same transmission increases the number of correct responses and reduces the number of wrong responses. This approach increases the work load on transcribers, since there is a duplication of effort. However, for important transmission, this duplication may be justified. Different team approaches might be used, depending on the content of the material.

8. Control of Auditory Fatigue (Temporary). Research indicates that stimulation of the auditory nerve with noise for some period of time will raise the threshold necessary for the ear to perceive a signal in the absence of the noise. How (if at all) this may affect the transcribers' performance will be determined, and means for minimizing this effect sought.

Scanners

1. Screening of Transmissions as a Standard Procedure. Screening of all incoming transmissions could result in the identification of transmissions of trivial content or of such poor S/N ratio [illegible] to make transcription useless. It may be possible to rate the useful tr[illegible]ions in terms of difficulty and importance so that this information c[illegible]e used to assign priorities to the transmissions and guide the assignment of transmissions to transcribers consistent with ability to transcribe. Although time is required for screening, overall man-hours may be saved by a reduced transcription workload. Other problems would have to be researched. Should one person do all of the screening, or should there be a trade-off between screening and transcription? Who are the best screeners? How useful is speech compression in the screening function?

2. Scanning Requirements. What is the degree of agreement among scanners (screeners) in classifying transmissions as to type of report required? If poor, what causes the variance? It is hypothesized that causes may include transmission clarity, simplicity, number of idioms, number of hard words, number of unknown words, length, and priority disagreements. Training, SOPs, aids, in-house instructions, and so forth, may be important determiners.

Checker

1. Effects of Suggestions on Checker or Helper Performance. Helper in this context refers to another transcriber or analyst from whom the transcriber requests assistance to help solve some problem with a transmission. As the checker or helper checks the accuracy of the transcriber's output, does the content of the transcription or gist suggest the meaning of the transmission so as to bias the checker or helper? If yes, develop techniques to control for this bias.

2. Prediction of Need for Checking. The first step would be to determine the amount of checking that occurs and the resulting gain in accuracy. Given that this is expensive in time, but a necessary function, the transcriptions to be checked would be computer-predicted by such variables as transcriber confidence and experience, quality of transmission, value of information, etc. In this manner, checker time would be devoted to those transcriptions that are worth checking.

3. Checking Techniques. Different techniques such as random sampling, request only, poor quality only, etc., would be developed and compared to determine which would reduce the time spent checking.

Aids, On-the-Job Training, and Proficiency Maintenance

The projects presented below envision a computer-linked system that could provide the transcriber with retrieval assistance, requirements information, storage of output, and so forth. The proposed projects could be done manually in a different format.

1. Computer-Assisted Instruction for Initial Training and for Proficiency Maintenance. Based on the type of transcription done and content of messages, training modules would be developed and stored to train new transcribers or update experienced ones in special areas such as critical words, names, places, and so forth. In addition, embedded training in the main computer would train all new transcribers on how to use the computer system.

2. Train Transcribers on Noisy and Distorted Transmission. It has been shown that 2 to 3 hours of training per day in listening to noisy or distorted transmissions for 5 or 6 consecutive days improves performance on poor quality messages. The performance reaches a plateau in this length of time. How often refresher training is required in an operational setting would have to be determined.

3. Development of a Training Package for Gisting. Gisting is usually acquired on this job. If it were taught on the job or prior to job entry, the new transcriber would become proficient sooner and would perform in a manner uniform with others in the group.

4. Development of a Time Expenditure Aid. The time required to process transmissions and prepare a transcription or gist will be determined for a number of transmissions. The frequency with which an undue amount of time is spent in such processing will be determined. If the number of transmissions requiring an excessive amount of time is found to be quite large, an aid will be developed to show the transcriber the amount of time that should be spent--computation would be based on variables including criticality, difficulty of transmission, transcriber ability, sound quality, and time available. Time versus completeness curves would be generated.

5. Design and Develop a Requirements Menu. Computer access to this menu would provide the transcriber with the latest information on mission requirements by area--what to report, time criticality, names and places of interest, priorities, and so forth. This would partially replace analysts' briefings of transcribers, insure timely updating, and provide new transcribers with a ready reference of area mission requirements.

6. Design and Develop a Set of Job Aids with a Menu. Many job aids such as dictionaries, requirements, updates, place/name information, and so forth could be more useful if stored conveniently in the main computer or locally in a "smart" terminal. A determination of what, where, and how

is necessary. Other job aids previously rejected as too cumbersome for manual systems should be reconsidered for possible inclusion in the new system.

7. Determination of the Frequency with Which Transcriber Aids Are Used. This may help determine what should be stored in the computer. However, frequency of use in manual systems may depend upon the cumbersome nature of the job aid, as well as on its utility. A useful job aid may be used little because it is hard to use in the manual mode.

Man-Machine Interface

Too often systems are designed without consideration of the operator of the system. User needs are translated into products by nonusers without checking back with the user to determine problems. The user often does not know all the problems associated with a systems interface or what new problems will emerge in the new system. Projects proposed here are general; solutions depend on the design specification of a particular system.

Develop a User Language for Computer Interactions. The essential idea here is to use transcriber language in interaction with the computer. At least two aspects could be attacked--query language and mixed initiative interactions. Studies in the realm of query language would specify and assess query language design features to increase the efficiency of man-computer dialogue by making query language easier to learn and use by the transcriber or analyst. Development of mixed initiative systems can improve the man-computer dialogue by volunteering information appropriate to the inferred intent of the query, prompting or "stepping" the user through complex tasks, diagnosing errors using contextual information to make feedback more specific, and automatically routing relevant information to the user.

Keyboard Design. For most computerized work stations, a determination should be made of the number of function keys required by the operator, their position as determined by frequency of use, and the grouping of sets of keys by function. Certain functions require special care to reduce errors that are especially wasteful of time. Any type of "destruct" key should be designed or placed to avoid accidental keying. Possible techniques are double entry, raised lettering, and color coding. The trade-offs involved in the use of a function key as opposed to a typed command input must be determined prior to much of the system design.

Experimental Station. Ideally, an experimental station should be developed to test the adequacy of the man-system interface in both hardware and software This facility must be modular in design to allow for easy programing and the addition, movement, or deletion of operator interface equipment, such as function keys, ancillary displays, work space arrangements, and so forth.

Feasibility of Using Standard Form(s) for Reporting. What is reported is a function of requirements, message content and readability, and operator-related variables. If research on present-day operations indicates a need for increased completeness in reporting and/or a reduction in the time required for report preparation, standard forms for reporting could help to

insure that everything required and nothing superfluous is reported. The individual forms would be based on the requirements imposed on that type of traffic for the readability of the message.

Need for Menus. A wide variety of information probably will be required in the computer data base as an aid in the transcription process. Most transcribers will use only a small subset of this information as it applies to their traffic. A menu approach, whereby all information available is displayed to the operator upon command, would enable the operator to "remember" what is available and to obtain particular information easily without referring to the operation manual.

Computer Malfunction Procedures. Although extensive time delays can be obviated by use of "smart" terminals, temporary delays can debilitate user motivation and system acceptance. The system should provide a set of recovery aids to enable the transcriber to correct minor problems. Manual backup procedures should be developed if computer malfunction problems become too disruptive.

Transcriber Motivation and Job Satisfaction

In industry, questionnaires are used frequently to assess worker attitudes and opinions concerning the suitability of the job environment, machines used, supervision received, adequacy of individual performance, and so forth. The purpose behind such surveys is to determine the existence of any incipient problem areas before they reach a critical stage. The motivation and job satisfaction of the workers can be seriously degraded by disruptive factors inherent in the job. To keep managers and transcribers informed concerning conditions of the work environment, projects like those listed below should be conducted.

Providing the Transcriber with a Personal Scorecard. This technique is visualized for use in a computer-linked system. The impersonal computer would provide the transcriber (upon request alone) with a personal scorecard summarizing, on a weekly or monthly basis, the number of transmissions transcribed, the number of times transcriptions/gists had been accessed by an analyst, and the number of times transcriptions/gists had been used in a report. Team and group averages could be provided for comparison purposes. New transcribers could evaluate their progress as they become more experienced.

Specific Questionnaires for Assessing Attitudes and Perceptions of Transcribers. These would be developed in the language used in the organization concerned to determine transcriber satisfaction with equipment, knowledge of the job, adequacy of feedback concerning performance, and so forth.

Assessment of Transcriber Output

Transcriber output can be evaluated after the fact by experts who listen to the same transmissions and then rate the transcriber's output. A method of predicting the utility of the transcriber's output without requiring

another person to do the same task would require less time and be highly desirable. To attain this goal, several projects are proposed.

Transcriber Confidence Ratings As a Measure of Output Utility. Research has shown that a positive tetrachoric correlation (r_{tc} = +.78) exists between transcriber confidence ratings and transcription accuracy. Transcription with high confidence ratings could be accepted as prepared. Those with low confidence ratings would be sent to a checker for verification.

Development of a Rating Scale for the Periodic Assessment of Transcriber/Gister Performance. The intelligence analysts who use the outputs of specific transcribers have a definite impression concerning the average completeness and accuracy of those outputs. Development of a standard rating scale would provide ratings of transcriber output on a common base that would tend to control for inter-rater differences.

Value Rating of Transcriber Output. The computer could automatically tag a transcription/gist with an indication of the "value" of its content in terms of importance, accuracy, and completeness. The prediction equation would use variables such as transcriber's confidence rating, transmission readability index, target difficulty index, and transcriber's ability. The analyst would use this information to help determine what transcripts to view first or, if important, which require additional transcription. The checker could use this information to help determine which transcripts require checking.

Selection of Transcriber Trainees

This is a long-range effort that can have little immediate payoff. Several documents in the literature refer to the judged inadequacy of the current aptitude criteria used in the selection of U.S. Army transcribers. To select a group of trainees using the recommendations of these researchers, train them, provide them with ample job experience, and then assess their performance would require a great amount of time.

Determining selection factors from a group of present transcribers assumes that the range of proficiency represented in the group is very large. Desirably, it would range from the extremely able to the unsatisfactory. Operationally, such a range is probably not attainable. During language training the poorest were probably dropped. On the job, those who do poorly are either discharged or quit, so that the range of talent is likely to be rather narrow. Two approaches to selection of trainees are given below.

Test Battery for Selecting Transcriber Trainees. A battery of selection devices over and above the ones currently in use has been recommended. The additional selection devices include the ability to play a musical instrument, puzzle-solving behavior and ability, measures of hearing and tonal discrimination, short-term and long-term memory, conceptualization ability, English language ability, motivation, and some indicator of job stability.

Feasibility of Employing a Job Sample Approach to Selection of Transcriber Trainees. It is recommended that a set of calibrated materials be

developed and used to identify potential transcriber trainees. Transmissions similar to the Sentence Intelligibility Lists developed at the Harvard Psycho-Acoustic Laboratory would be used as stimulus materials. Applicants for transcriber training would be given these job sample materials with several different levels of noise and/or speech compression. The sentence lists would be in English, and the applicant would make his responses in English. Applicants who achieve a predetermined cutoff score on this job sample selection device would be accepted for training.

Miscellaneous

The following projects are judged to have merit but do not seem to fit into any of the previous areas.

Effect of Distraction and Extraneous Noise on Transcriber Performance. This project is concerned with the effects of ambient noise and distraction in the work space. Is performance improved, unchanged, or worsened when the transcriber works in isolation in a soundproof booth? Distraction through all senses is of interest here, not just auditory distraction.

Determination of Optimal Organization Structure, Based on the New System. The introduction of the computer-linked system may bring about changes within the organizational structure. Since work methods will be affected, organizational composition may be more effective with modification.

Management Reports. How many routine and special reports are made? How much time is required for these reports? How much computer time will be dedicated to the preparation of such reports?

Determine a Functional Organizational Chart for the Present System. The organizational structure for management and administrative purposes is described. For comparison purposes, it would be useful to determine the structure of the present system as a function of how the various organizational elements actually perform their jobs. For example, which groups do things in a similar fashion but differ organizationally? Answers to such questions will be obtained in the development of a functional organizational chart.

Computers as Research Tools in Computer-Linked Systems. The computer in such systems will make it possible to collect data in a convenient fashion, to determine the relative effectiveness of alternative work methods, to conduct experiments, to statistically analyze data, and so forth. Long-term effects could be measured easily, provided that some thought is given as to what data will be required.

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APPENDIX A

TRANSCRIBER QUALIFICATIONS

CMF 98
ELECTRONIC WARFARE/SIGNAL INTELLIGENCE VOICE INTERCEPTOR (EW/SIGINT Voice Intcp)
MOS 98G

Summary

Conducts and supervises intercept of foreign voice transmission in a tactical or strategic environment. Prepares voice activity records. Conducts EW activities.

Duties

MOSC 98G10: Operates equipment configurations to collect and make written records of stereotyped foreign voice radio transmissions which are comprised of limited terminology and simple syntax structures. Deploys with tactical support units and assists in installation and operations of equipment. Makes voice servicing announcements. Identifies languages spoken in the geographic area to which assigned. Categorizes foreign voice signals by activity type. Scans written foreign language material which is predictable in subject matter and language for key words and indicators. Provides translation assistance to nonlanguage qualified analysts. Extracts obvious essential elements of information (EEI) from voice radio transmissions to support mission reporting requirements. Performs electronic support measures (ESM) for EW operations. Operates communication equipment for EW/SIGINT reporting and coordination.

MOSC 98G20. Intercepts, identifies, and records designated foreign voice transmissions. Operates equipment configuration to intercept and produce written record of nonstereotyped foreign voice radio transmissions.

MOSC 98G30: Supervises voice communication intercept activities. Operates sophisticated equipment configurations to collect and simultaneously produce on-line activity records of complex foreign voice radio transmissions containing technical terminology, advanced grammer/syntax, and colloquial conversational forms. Directs voice signal collection and processing activities. Determines collection and processing priorities. Identifies and performs limited analysis on nonclear voice and nonvoice signals. Implements EW/SIGINT emergency action plans.

MOSC 98G40: Supervises voice communication countermeasures activities. Refines EEI requirements for identification and extraction. Performs voice intercept and processing of highly complex foreign voice radio transmissions.

MOSC 98G50: Serves as EW/SIGINT Voice Operations Chief. Evaluates and defines job requirements and system capabilities for COMINT linguist resources.

Qualifications

	MOSC 98G10	MOSC 98G20	MOSC 98G30	MOSC 98G40	MOSC 98G50
Must possess the following cumulative qualifications:					
a. Know:					
(1) A specified foreign language with the following knowledge requirements:					
(*a*) Vocabulary (aural recognition):					
1. 5000 6000 words	X				
2. 6000 8000 words		X			
3. 8000 10,000 words			X		
4. 10,000 15,000 words				X	
5. 15,000 + words					X
(*b*) Technical terms:					
1. 500 750 items	X				
2. 750 1000 items		X			
3. 1000 1500 items			X		
4. 1500 3000 items				X	
5. 3000 + items					X

Qualifications—continued

	MOSC 98G10	MOSC 98G20	MOSC 98G30	MOSC 98G40	MOSC 98G50
Must possess the following cumulative qualifications:					
(c) Grammar and syntax:					
1. Fundamental to complex	X				
2. Complex		X			
3. Advanced			X		
(*d*) Total knowledge of numbering system	X				
(*e*) Function words:					
1. 70-85 percent of all existing	X				
2. 85-90 percent of all existing		X			
3. 90-100 percent of all existing			X		
4. Total knowledge				X	
(*f*) Kinship terms/forms of address:					
1. 70-85 percent of all existing	X				
2. 85-90 percent of all existing		X			
3. 90-100 percent of all existing			X		
4. Total knowledge				X	
(*g*) Writing systems except ideographic systems—total comprehension	X				
(*h*) Ideographic writing systems:					
1. Write 350 and read 1000 characters	X				
2. Write 500 and read 1500 characters		X			
3. Write 750 and read 2000 characters			X		
4. Write 1000 and read 2500-3000 characters				X	
5. Write 1500+ and read 2500-3000 characters					X
(2) Basic radio wave propagation theory	X				
(3) Basic intercept equipment operations and theory	X				
(4) Applied EW/SIGINT management			X		
b. *Physical profile:* 222121	X				
c. *Aptitude area:*					
(1) ST(GT)	X				
(2) DLAB	X				
d. *Security Clearance:* TOP SECRET	X				
e. *Other:*					
(1) Special intelligence access	X				
(2) Audiometer test	X				
(3) Sound discrimination test (phonetic)	X				
★(4) Type 20 words per minute	X				
(5) Use of this MOS in non-USASA or non-EW/SIGINT units must be authorized by HQDA and will be used after clearing each specific case with HQDA (DAPC-MSP), Alexandria, VA 22331	X				

★ Additional Skill Identifiers

Code	*Title*
C8	Transcriber/Gister
K3	ECM Operator

Related Civilian Occupations

★DOT classification	*Code*
Translator	137.267-018
Interpreter	137.267-010
Federal civil service classifications	*Code*
Cryptologic Linguistic Technician	1212C
Signal Collection Technician	1621C
Translator	1213C
Voice Transcriber Analyst	1213B
Voice Transcriber	1213C

Standards of Grade Authorization

Line	Duty Position	Code	Rank	Number of positions authorized*										Explanatory Notes
				1	2	3	4	5	6	7	8	9	10	
1	EW/SIGINT Voice Collector ECM Voice Operator.	98G10	SP4		1	2	3	4	4	5	5	5	6	
★2	EW/SIGINT Voice Interceptor Voice Transcriber/Gister COMINT Translator ECM Voice Operator.	98G20	SGT	1	1	1	1	1	2	2	2	2	2	Grades of additional positions will be determined in same pattern.
3	EW/SIGINT Voice Interceptor/ Supv.	98G30	SSG								1	2	2	
4	EW/SIGINT Voice Interceptor/ Supv.	98G40	SFC											Generally authorized for supervision of shifts or units of 20 or more personnel or for supervision of 2 or more teams with a minimum of 3 or more voice operations specialists or 4 or more voice interceptors.
5	EW/SIGINT Voice Operations Chief.	98G50	MSG											In field station or higher headquarters engaged in SIGINT voice collection activities.

*Blank spaces in this column indicate not applicable

APPENDIX B

LITERATURE SEARCH SUMMARY

This appendix describes the steps taken to determine the relevant literature in communications intelligence research that focuses on the job of the transcriber/gister. Some of the documents requested arrived too late to be incorporated in the documentation summary. These are cited here for the information of others interested in this research area.

Based on reports describing research conducted by research scientists of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) in the area of communications intelligence, a list of key words and phrases was developed. This list appears as Exhibit A. A subset of 11 categories was generated from the longer list, and this set of key words and phrases was used to search the various data bases available. Exhibit B contains this abbreviated list of key words. A search of the holdings of the National Technical Information Service (NTIS) and of Psychological Abstracts produced 452 titles with abstracts. The frequency by key word category for each of the two sources appears in Table B-1.

The printouts for the data base search (User 646, 28 Jun 78) are held in the Human Factors Technical Area of ARI. Review of these abstracts produced the references cited in the report, plus an additional 14, which were requested from MITS. The titles of these 14 references are given in Exhibit C. Not all the documents requested reached ARI in time for this review. Twelve of the 14 requested are on hand. Number 8 on the list is no longer available from the Defense Technical Information Center (DTIC), and number 3 has not been received.

A second literature search was initiated through the DTIC, requesting a report bibliography covering research on communications intelligence. Both unclassified and classified (up to SECRET) holdings were requested. A list of key words was established and these embedded in a narrative statement form as required in Block 15 of DDC Form 4. Exhibit D shows a work copy of the form that was required for submission to DDC.

A Report Bibliography (Search Control No. 072356) covering unclassified reports was received from DDC. The abstracts or titles, where no abstract was given, were reviewed, and each entry was classified as to its judged relevance for transcriber research. The bibliography included a title index, and a rating was added at the left of each title, using the following code:

Symbol	Meaning		Number given this rating
D	Directly Related		9
R	Related		24
P	Possibly Related		123
Blank	Unrelated		436
		Total	592

The research reports cited in this bibliography have not been reviewed and are not reflected in the literature summary. The bibliography for classified reports was not received in time for this report.

Exhibit A

Key Words for Communications Intelligence

Binaural listening
Gisting
Attentive listening
Effective listening
Transcribers
Dictation stenography
Court report--stenotypy
Conference transcriber
Minute taking
Voice communication processing modes
Intelligence information extraction
Recapitulation
Voice radio-telephone communications
Outlining
Transcription
Translation
Verbatim transcription
Speech translation
Speech processing
Speech (sending & receiving)
Interrogator
Phonetics
Recapitulating

Communications research
Communications processors
Military communications system
Voice processing procedures
Interpretation
Speech compression research
Digital transmission of voice
Communication processing & analysis
Communications monitoring
Translation of verbal messages
Oral, voice communication
Voice processor performance
Note taking
Monitor performance
Methodology
Translator
Laboratory facilities
Intelligence systems
Information extraction
Intelligibility
Speech intelligibility
Signal-to-noise ratio
Summarizing

Exhibit B

Key Words Used for Literature Work

1. Listening, effective, binaural, attentive
2. Gisting
3. Transcriber performance
4. Speech processing
5. Note taking
6. Translation of verbal communication
7. Speech translation
8. Digital voice transmission
9. Speech intelligibility
10. Speech compression
11. Signal-to-noise and intelligibility

Table B-1

Research Report Frequency by Key Word and Source

Key word category	Data base NTIS	Psych Abs
1. Listening, effective, binaural, attentive	--	21
2. Gisting	1	5
3. Transcriber performance	3	23
4. Speech processing	30	--
5. Note taking	2	33
6. Translation of verbal communication	3	12
7. Speech translation	24	12
8. Digital voice transmission	50	--
9. Speech intelligibility	42	50
10. Speech compression	56	6
11. Signal-to-noise and intelligibility	64	15
Totals	275	177

Exhibit C

Documents Requested

1. AD-A047 240/7ST - The development of a computer speech processing system and its use for the study and development of processing methods for enhancing the intelligibility of speech in noise.

2. AD-A021 899/0ST - Robust speech processing.

3. AD- 451 036/8ST - State-of-the-art. Speech compression and digitization.

4. AD-A050 163/5ST - Performance measurements of the CVSD speech coding algorithm.

5. AD-A041 337/7ST - Noise suppression methods for robust speech processing.

6. AD- 849 465/0ST - Effects of selective system parameters on communications intelligibility.

7. NTIS/PS-77/0835/7ST - Speech intelligibility (A bibliography with abstracts).

8. AD- 288 850 - Speech compression. A DDC report bibliography.

9. AD-A007 247/0ST - Time and frequency resolution in speech analysis and synthesis.

10. AD- 781 754/7ST - Compressed speech: Potential application for Air Force technical training.

11. AD- 472 242/7ST - The effects of preemphasis, peak clipping, and deemphasis on the intelligibility of speech in noise.

12. AD-A011 709/3ST - Study and development of the INTEL technique for improving speech intelligiblity.

13. AD- 777 564/6ST - Reception of distorted speech.

14. AD-A024 705/6ST - Massed versus distributed practice in learned improvement of speech intelligibility.

EXHIBIT D

INFORMATION REQUEST

**R&T WORK UNIT SUMMARY/REPORT BIBLIOGRAPHY/
R&D PROGRAM PLANNING SUMMARY**

NOTE: No carbon is required in the completion of this form since the paper has been specially treated.

SEE INSTRUCTIONS ON REVERSE

FOR DDC USE ONLY

REPORT CONTROL NUMBER

RB NUMBER

1. FROM *(Complete name and address)*

2. DoD USER CODE

4. CONTRACT/GRANT/PROGRAM NUMBER

3. TYPE OF SEARCH REQUIRED

	WORK UNIT SUMMARY (Contractors & Grantees only)
	PROGRAM PLANNING SUMMARY (Contractors & Grantees only)
X	REPORT BIBLIOGRAPHY(AD)
	BIBLIOGRAPHY INDEXES
	CURRENT AWARENESS(CAB)

5. REQUESTER'S NAME AND TELEPHONE NUMBER

HAROLD MARTINEK (202) 274-9045

6. DATE REQUESTED

11 July 1978

11. DATE RESULTS NEEDED

20 July 1978

7. CLASSIFICATION *(Highest)*

	Unclassified
	Confidential
x	Secret

8. CHECK IF DESIRED AND AUTHORIZED

	Restricted Data
	NATO Only *(See Instruction No. 8 on Reverse Side)*

9. DEPTH OF SEARCH

x	Broad Coverage
	Highly Specific

10. TIME COVERAGE *(Limit to 10 years)*

10 years

12. REQUEST TITLE *(Unclassified) (Up to 45 Type Spaces)*

Communications Intelligence Research

13. REQUESTER'S REFERENCE *(Optional)*

14. REFERRAL SERVICE IF DESIRED

15. INFORMATION REQUIRED *(Submit request in narrative statement form)*

The Battlefield Information Systems Technical Area of the U.S. Army Research Institute for the Behavioral and Social Sciences has been requested to provide human factors support to several agencies in the COMINT (Communications Intelligence) area. To provide background data for this research, request that a literature search for results of research already conducted in the COMINT area be made. The job of the transcriber (MOS 98G) is the primary target. This man translates voice communications in a foreign language and summarizes or gists the content into a written report in English. Translating & summarizing voice communications is an abbreviated statement of the transcriber's job. The effects of signal-to-noise and intelligibility and communications jamming are two important limiting factors on the quality of the transcriber's performance and methods for minimizing these effects are critical for successful job completeness.

NOTE: Underscored words & phrases are possible keywords.

16. DATA TO BE USED FOR *(Optional. Describe your work problem in narrative statement form)*

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SEARCH INPUT		OUT CLASSIFICATION			REJECTS		REVIEWED BY		DATE	
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